

Meet “MASTER” — Modeling & Simulation Test & Evaluation Reform

Energizing the M&S Support Structure

JAMES F. O'BRYON

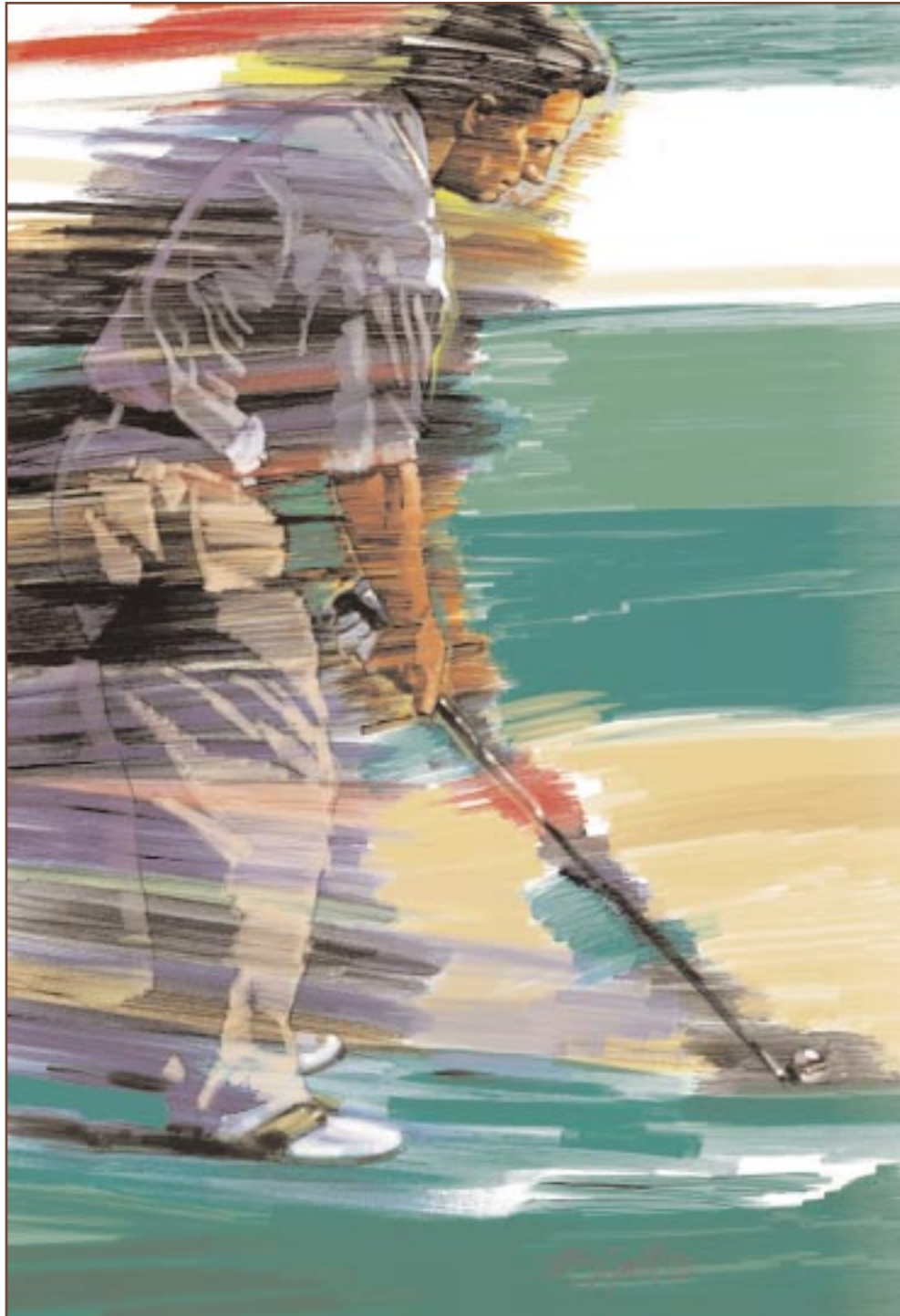
In the following few pages, I discuss my personal thoughts on an issue of paramount importance not only to the Department of Defense, but also to the nation's defense. My hope is that this article will provoke serious thought and meaningful action to resolve the issues raised.

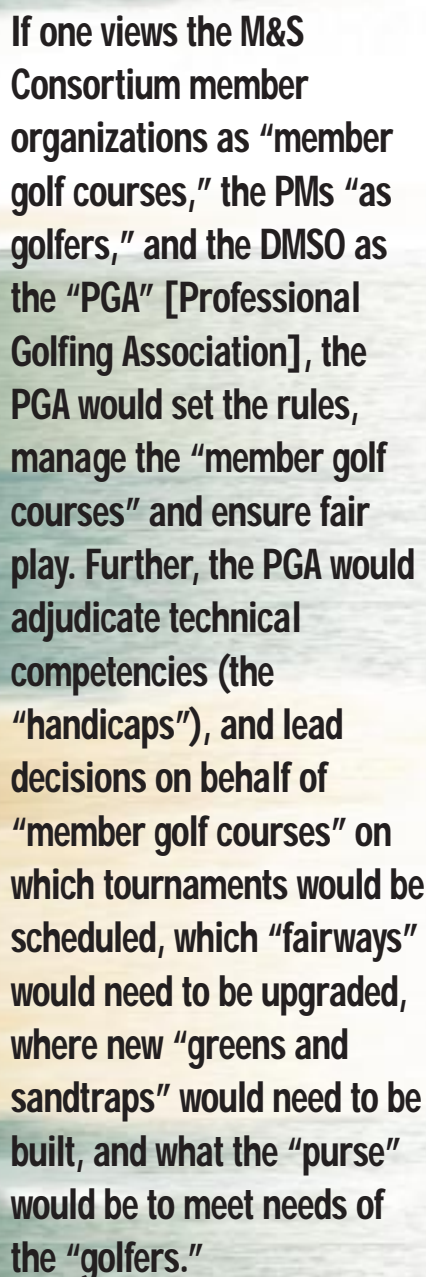
First, A Look Back

Since arriving in the Pentagon just over 12 years ago, and for more than a decade before that serving as a weapons analyst in the Department of Defense (DoD) infrastructure away from the Washington area, I have been witness to numerous and surprisingly similar technical and management discussions about the need to get the modeling and simulation capabilities of the DoD organized, incentivized, under control, and more efficient to better serve the weapons development and acquisition process.

These discussions included such issues as a common and meaningful model architecture, model inter-connectivity, language consistency, validation, model proliferation, and configuration control. They've also covered the problems of duplication, modeling “stovepipes,” the lack of meaningful and up-to-date documentation supporting M&S, and of course, the lack of model realism.

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If one views the M&S Consortium member organizations as "member golf courses," the PMs "as golfers," and the DMSO as the "PGA" [Professional Golfing Association], the PGA would set the rules, manage the "member golf courses" and ensure fair play. Further, the PGA would adjudicate technical competencies (the "handicaps"), and lead decisions on behalf of "member golf courses" on which tournaments would be scheduled, which "fairways" would need to be upgraded, where new "greens and sandtraps" would need to be built, and what the "purse" would be to meet needs of the "golfers."

During an M&S conference hosted at a military installation last year, over 200 participants from the Services and the Office of the Secretary of Defense, including myself, gathered to again discuss these persistent issues and, in particular, attempt to implement an initiative promulgated some two years ago by Dr. Paul Kaminski, the former Under Secretary of Defense for Acquisition and Technology.¹ The initiative, called the Simulation Test and Evaluation Process or "STEP," was an attempt to make M&S more of an integral part of the test and evaluation process. To quote its charter, "STEP is an iterative process that integrates both simulation and test for the purpose of evaluating the performance, military worth, and effectiveness of systems to be acquired."

Along with many others, I attended conferences and listened to expressions of concern about 1) why more money isn't being invested in realistic models and implied simulations; and 2) why our models are not more reliable and realistic.

All of these issues now force me to personally rethink why DoD has made little progress in getting its arms around the M&S issue.

A Problem Growing Progressively Worse

As the defense community continues to discuss these significant and pervasive problems and, on occasion, to make small incremental progress, the underlying problem gets progressively worse. At the same time, our weapons systems continue to become more costly and complex. It is also becoming more difficult to anticipate and test all of the possible permutations of combat conditions and threats against which they might be deployed.

Simultaneously, program managers face increasing budgetary pressures to cut back on system-development costs while pushing to accelerate the acquisition process and Acquisition Reform.

In a nutshell, virtually everyone seems to believe that we must *do* something or *fund* something. But exactly *what to do*,

how to play, who will play, who will pay, who will be paid to do it, and how much should be spent have not yet been spelled out and, as importantly, not yet incentivized and resourced. Effective incentives are needed, as are workable mechanisms to ensure that resources are available.

Current Ground Truth

In order to have an idea of what could be done, first we need to acknowledge some ground truths.

NO NEW MONEY.

Whatever solution we come up with, it is a near certainty that asking for and receiving new money will not be an option. It's no secret that the Department is struggling to keep adequate funding for the programs that are already on the table. Couple this with the growing threats and obligations around the world and it's easy to see that raising new money for M&S is a non-starter.

PMs AND PEOs CONTROL LARGEST FUNDING BLOCKS.

Program Managers (PM) and Program Executive Officers (PEO) control the bulk of the redirectable (discretionary) funding. A quick look at the DoD FY99 budget reveals over 200 defense programs with active funding, ranging from large Acquisition Category (ACAT) ID programs—some exceeding \$50 billion—down to very small ACAT IV programs, which are in the low millions. These 200+ programs tip the scales at many billions of dollars.

Conservatively, hundreds of millions of dollars, if not several billion, are being spent annually (DoD expenditures were estimated at between \$1.3 and \$1.6 billion annually five years ago) on diverse efforts involving M&S across the DoD.² M&S investments have grown geometrically over the intervening five years since this estimate was made.

If one goes to the PMs themselves, what do they estimate spending on M&S? This question was informally posed to a few PMs and former PMs. While no PM had a firm estimate, the answers came back in a broad range, from a low

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O'Bryon began work in the Pentagon as a member of the Senior Executive Service in November 1986 as Assistant Deputy Under Secretary of Defense, a position created in response to legislation enacted by Congress that requires realistic Live Fire Testing be performed on DoD's major conventional weapons and an independent Live Fire Test Report be prepared and submitted to Congress before these systems enter full-rate production. Since that time, he has also served within the Office of the Secretary of Defense as Deputy Director, Test and Evaluation; as Director, Live Fire Testing; and as Acting Director, Weapon Systems Assessment.

O'Bryon has more than 25 years of leadership experience in weapon-system technology and survivability, and has testified before Congress on several occasions regarding weapons acquisition and testing. His technical experience includes work in the biophysics department at IBM's Thomas J. Watson Research Center; the Actuarial Department at the home office of New York Life Insurance Company; the Ballistic Research Laboratories; the Army Materiel Systems Analysis Activity at Aberdeen; and, since 1986, the Office of the Secretary of Defense at the Pentagon.

Born in Schenectady, N.Y., O'Bryon received his undergraduate degree in Mathematics. He also has graduate degrees from The George Washington University in Operations Research/Management Science and from the Massachusetts Insti-



tute of Technology (MIT) through the Electrical Engineering Department.

O'Bryon is also involved in many outside activities and interests: songwriter and recording artist with four albums to his credit; soloist and instrumentalist at various church and community functions; and conference speaker on mathematics, education, music, and the patent/copyright system.

In addition to building his own harpsichord, he worked as a radio announcer and newscaster for *WRBS* in Baltimore for 15 years, and served as music director for churches in three states. Currently, he serves on the Board of Trustees of a private college, maintains an active speaking and concert schedule, and is an active member of the MIT Education Council.

An author of over 60 technical publications and holder of several copyrights, O'Bryon's honors include Who's Who in America, Outstanding Young Men in America, Sigma Xi, and Distinguished Lecturer at the Defense Systems Management College. He is also a Fellow of the Center for Advanced Engineering Study at MIT and is Chairman of the T&E Division of the National Defense Industrial Association.

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of 3 percent up to as much as 15 percent of the total budget controlled by the PM.

PMs AND PEOs WILL BENEFIT THE MOST.

Although M&S benefits the in-house labs, development houses, and other activities, PMs, by far, benefit the most from the efforts of the M&S community. These models assist them in R&D, allowing trade-offs between cost, weight, maneuverability, susceptibility, range, delivery accuracy, reliability, vulnerability, and a host of other factors. If VV&A'd properly, these models can yield multi-million-dollar savings on the resultant systems as well as shortening the acquisition cycle. Future PMs will also continue to reap the benefits as additional programs come along.

PMs HAVE SHORT TIME HORIZONS ON THEIR PROGRAMS AND HENCE, ON THEIR INVESTMENT DECISIONS.

Anyone familiar with the current PM system of weapon-system management would agree that the time that a PM serves is typically about three years, give or take a year or so. Under this management paradigm, the typical PM of a multi-billion dollar program is responsible for the overall management of his or her assigned program through only one milestone. Rarely is a PM involved in two milestones, let alone more.

Since PMs are so highly trained and motivated to meet their acquisition milestone and budgetary goals and to move on in their careers (having met these important and highly visible criteria), there is little motivation or incentive for them to invest in realistic M&S since the amount of time needed for the PM to see the benefit of any M&S investment has been historically beyond his or her tenure as PM. Furthermore, little incentive structure exists for a PM to invest in these models, especially when the funds could be used for other, more timely and visible investments in the program at hand.

Hence, in making investment decisions among M&S options, PMs are driven by

the short-term goals of getting their program through the acquisition milestone wickets while trying to minimize the risk of time delays and cost overruns. Nor does the current acquisition structure offer motivation to the PM to make significant investments in M&S on the basis that such investments may also mutually benefit other current or future programs.

Regarding the need for PMs to invest in M&S, the current Under Secretary of Defense (Acquisition & Technology), Dr. Jacques S. Gansler has made clear that he “expects programs to make the up-front investment in modeling and simulation application technology, and will be looking for evidence of that investment in program planning and execution.”³

REALISTIC M&S IS NOT NECESSARILY VIEWED AS A BENEFIT BY THE PM.

This point is perhaps non-intuitive, so allow me to explain. Most weapon systems have a number of what are often called “Measures of Effectiveness” or MOEs. These may take any number of forms, such as probability of kill (Pk) given an engagement or radar cross-section.

History has shown that, typically, the simpler the models characterizing weapon-system performance, the more optimistic their results since they often fail to take into account the realities of the “dirty battlefield.” Such things as battlefield obscuration, weather effects, false targets, mobility, jamming, C3I, terrain features, and a host of other factors can all be pivotal factors in lowering estimates of actual system performance in a realistic hostile and stressful combat environment.

To bring this discussion into focus, let me take an example case of a hypothetical fire-and-forget weapon with an MOE calling for a 60-percent probability of kill given a shot (Pk/s). Let’s assume that this weapon is intended to be dropped from an aircraft, descend on a parachute while scanning the target area, sense the armored vehicle it is to attack and detonate, send a slug down onto the vehicle, and (hopefully) destroy it.

“I am requiring that the simulation, test, and evaluation process – let’s call it STEP – shall be an integral part of our test and evaluation master plans [TEMPs]. This means our underlying approach will be to model first, then test, and then iterate the test results back into the model.”

—Dr. Paul G. Kaminski, Former USD(A&T)
ITEA Convention, October 1995

Early estimates performed in support of the PM might show that the estimated Pk/s is approximately .91 – well above the .60 required. Shortly after this, someone notices that the terrain was assumed to be flat and does not represent the terrain of its expected combat theater. Following the addition of hilly and vegetated terrain to the model, estimates of Pk/s drop slightly to .86 due to terrain masking and intervisibility.

Shortly afterward, another “enhancement” is added to the model to account for wind. This increases the delivery error and also causes some sensor scanning gaps on the ground due to the parachute motion caused by the gusting wind. This drops the estimates to around .78.

By this time, the PM may be feeling somewhat concerned but still not enough to panic. Well, no panic until another M&S realism factor is added: the fact that the targets must be moving and not simply stationary targets waiting to be hit. Adding moving targets further

complicates the aiming algorithm and delivery error, further dropping the Pk/s to .62. By this time the PM has begun to wonder how much of this “M&S realism” he or she can really tolerate, let alone actually pay for.

But it’s not over. The data start to roll in regarding the reliability of the sensor and aiming algorithm, further dropping the performance estimate, this time pushing the Pk/s below the required .60. As time goes by, additional model realism sets in as fratricide, countermeasures, false targets, and a host of other realism enhancements are added to the models supporting the PM.

One can readily conclude that realistic models can actually serve as a *disincentive* to PMs who might want to use an M&S tool for public relations rather than for greater understanding of the system. Why invest significant funds to build a model or simulation more complex and representative of real-world conditions, only to have it yield more realistic, and probably lower, estimates of performance. In other words, why spend more money for bad news?

THE GOLDEN RULE: THEM THAT HAVE THE GOLD MAKE THE RULES. In the United States, the PM system has been purposely designed to place both great autonomy and heavy responsibility on each PM to get the job done. There is nothing innately wrong with this either. Because of this, PMs are driven to invest their time and energies in those areas where the return will match the short term of their PM tenure, all the while hoping not to create more problems than they solve.

I’m not blaming the PMs for this thought process since there is little incentive structure to do otherwise. It’s a tough business trying to manage these multi-billion dollar programs, balancing the numerous requirements placed on them by the Pentagon, Congress, the private sector and their career demands.

Since no clear incentive structure currently exists within the PM system to invest in realistic modeling for the long

term, PMs have made investments that, for the most part, have been disorganized across the DoD, with funding being “shotgunned” out to any number of contractors and/or in-house labs to answer shorter-term questions.

SO WHAT IS THE CURRENT M&S SITUATION?

Significant funds are being spent reinventing models and sub-models as successive PMs arrive in support of various programs. And in some cases, these same models may possibly be resold back to the government under a new name.

Another situation may be that a model might be written from scratch, without the knowledge that the model may already exist. Or, the government may have already paid for a model under one PM’s program that could meet the needs of another PM with little or no modification.

The proclamations of such policies as the STEP process and the Pentagon’s Simulation Based Acquisition (SBA) Initiative, and other similar initiatives may well not rise to the levels of success originally intended and projected. As a result, *the people who are in the best position to fund and benefit from realistic M&S may not do so.*

AIM AT NOTHING AND YOU’RE SURE TO HIT IT. IS THERE A SOLUTION?

I believe that there is a solution to the current problem. But it will require some major shifts in the way DoD does business — shifts in the way we manage and fund M&S, test and evaluation — real reform. It will require change in the way we organize and oversee this process. Last, but certainly not least, it will also require a major shift in the way PMs think about funding M&S and how the defense infrastructure responds. The following concept recognizes and deals with all of these factors.

My Proposal — Meet “MASTER”

I call this change, “Modeling and Simulation Test and Evaluation Reform” or MASTER. This is not a small perturbation in the way M&S is managed. It in-

**“We must fully
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—Dr. Jacques S. Gansler, USD(A&T)
National Defense, September 1998

volves a significant shift in current procedures. It is not intended as a challenge to or substitute for SBA or STEP but rather as a means of helping to achieve the goals established by these two important initiatives.

The first action required would be to identify the characteristics of the M&S support historically needed to meet the needs of the acquisition community. I would call these “M&S Vectors,” each vector being a specific category of technical modeling expertise. At this point, let me list a few possible M&S vectors. Such a list might include M&S expertise in:

- Terrain Modeling
- Weather Modeling
- Geometric Solid Modeling
- Aerodynamic Flow/Flight Modeling
- Target Signature Modeling
- Sensor/Fusing Modeling
- Smoke/Obscuration Modeling
- C3I Modeling
- Electronic Warfare Modeling
- Ballistic Modeling
- 1-1 Combat Modeling
- M on N Combat Modeling
- Vulnerability/Lethality Modeling

- Logistics Modeling
- Others

In-house government R&D centers would be identified (perhaps through the use of a Blue Ribbon Panel) to lead each M&S expertise vector. These centers would be responsible for assuring that the models in the technology vector for which they are responsible are verified and validated. This accountability would extend to those models and simulations within their own organizations as well as others outside their organizations that might possess other unique capabilities that the vector lead organization could also call upon. In each of these centers would reside state-of-the-art knowledge in each center’s assigned technical vector, along with lead M&S responsibility for that same vector throughout DoD.

To provide needed M&S support to PMs in their respective vector disciplines, each center would also have the authority and responsibility to decide where model funding would best be allocated. In turn, these lead centers would be responsible for providing PMs timely support in the model vector for which they are responsible.

For example, when a PM is first assigned to a weapon system, the PM would approach the Consortium membership, explaining what the system is intended to do and what issues relate to its development and performance. The Consortium membership would then identify which M&S vectors are needed to support the PM, and assume responsibility for providing M&S support to the PM in those areas of responsibility, extending the edges of extant models and modifying others to meet the PM’s needs. In some cases, Consortium members might even assign professionals to the PM’s office to assist on an interim basis.

Why a Consortium?

The word “Consortium” is carefully selected since it carries with it the idea of an organism made up of a number of entities, bound together by a common purpose. It would not require the establishment of new entities, merely the

realignment of responsibilities of those entities that already exist. This "Consortium," an organization made up of personnel drawn primarily from the civilian sector of DoD, would have the following responsibilities:

- Implement policy regarding established M&S architectures and codes.
- Assure that all codes under their oversight are verified and validated as well as accompanied by documentation explaining both the capabilities and limitations of each code to avoid misapplication.
- Maintain a repository of codes for access and application on behalf of other PMs, assuring that codes are not reinvented with each successive PM, but rather are upgrades, expansions, or modifications of those that already exist.

Does DMSO Have a Role to Play?

Absolutely! A very central, strategic, and critical role. The Defense Modeling and Simulation Office (DMSO) was created in 1992 "to both carry the mantle and promote the mantra of simulation's enormous potential for streamlining acquisition and development of new weapon systems, plus enhancing training effectiveness and readiness."⁴ It was set up with the hope of bringing a certain degree of discipline and organization to DoD's M&S efforts.

In the early years, immediately after the creation of DMSO (1992-1994), the budget provided was executed through a mechanism called "focus call" — a broad range of, arguably, mostly disjointed M&S requests from a wide variety of sources. Since the development and publication of the DoD M&S Master Plan (1994-1995), the investments by DMSO were redirected toward establishment of the key enablers called for in the Master Plan.

The fruits of these investments are only beginning to be realized now with the establishment of the High Level Architecture (HLA) as the DoD M&S Technical Architecture standard in 1996, and its acceptance by the industrial Object

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Defense News, April 1998

Management Group (OMG) and the Institute of Electrical & Electronics Engineers (IEEE) as commercial standards.

The North Atlantic Council, in their approval of the first NATO M&S Master Plan, recently adopted the HLA in December 1998. Additionally, it is expected that 1999 will see the embracing of the Synthetic Environment Data Representation and Interchange Specification (SEDRIS) by key M&S development communities in the commercial and military markets.

While these steps show positive movement in development of key M&S infrastructure areas, there is much more Enterprise-level work that needs to be done.

To illustrate, let me use (for lack of a better analogy), the Professional Golf Association, the PGA or, perhaps, the United States Golfing Association (USGA).

If one views the M&S Consortium member organizations as "member golf courses," the PMs "as golfers," and the DMSO as the PGA, the PGA would set the rules, manage the "member golf

courses" and ensure fair play. Further, the PGA would adjudicate technical competencies (the "handicaps") and lead decisions on behalf of "member golf courses" on which tournaments would be scheduled, which "fairways" would need to be upgraded, where new "greens and sandtraps" would need to be built, and what the "purse" would be to meet needs of the "golfers."

In essence, DMSO would establish the set of rules within which the entire Consortium membership would be managed, and all play would be executed. They would serve as the DoD's "Windows" protocol establishers, architecture writers, and the qualifiers and disqualifiers when member organizations or individual members don't play by the rules.

Another key point is that DMSO would not write any code. DMSO would oversee development and provisioning of key infrastructure enabling software that is developed commercially or through other development members of the Consortium until such time as a viable commercial marketplace for the applications could be fostered and sustained.

The decisions on which M&S needed to be upgraded (and invented from scratch if needed) would be made by the technology vector members of the Consortium charged with the lead responsibilities for specific areas of M&S. Even then, the modeling would often not be done within that lead organization's facility, but would be funded at the facility that represented the state-of-the-art in that M&S technical area, even an organization outside of the DoD.

The recently strengthened Office of the Director, Defense Research and Engineering within the Office of the Secretary of Defense, would play a vital role in the success of this effort.

M&S — More Success on Training Side Versus Acquisition Side

Clearly, the Department has experienced more success in its M&S training activities than in support of its acquisition activities. In fact, Navy Capt. James Hol-

lenbach said recently that “Simulation has to prove its worth to protect its dollars. The consensus is [the M&S community] has had the most [M&S] success in the training realm, some in analysis, and the least penetration with acquisition-oriented M&S.”⁵

Part of this success has been the close coupling that exists between the training community and those who build their trainers. The MASTER concept should help address this problem on the acquisition side by similarly bringing closer together the builders and users of these acquisition models and simulations.

“MASTER” and Its Benefits — A Brief Recap

MASTER is a management approach to M&S in support of DoD’s policy of Simulation Based Acquisition and Acquisition Reform. It will ultimately provide critical mass funding to DoD’s M&S efforts, add discipline to the development of M&S, ensure that the funds are expended to further the state-of-the-M&S-art, including its VV&A.

In addition, it would add consistency and efficient connectivity across various model vectors currently being developed, free up the PMs’ time and concerns about realistic M&S support, and assure that realistic models and simulations are exercised in designing, testing, evaluating, training, fielding, and employing our defense systems in combat.

The benefits are many, but let me cite a few:

- MASTER would assure that PMs receive the best and most realistic model support for their programs.
- By establishing necessary Consortium protocols for model architecture, languages and other M&S characteristics, no funds would be invested in model development or upgrades unless such development or upgrades met established protocols, thereby facilitating interoperability. Rather than spending significant funds reinventing and re-buying codes that exist or exist in part, MASTER would direct

“Let me take this opportunity to firmly state my commitment to the use of M&S in the acquisition of our weapons systems.”

— Dr. Jacques S. Gansler, USD(A&T)
DoD Memorandum, March 1998

model investment funds toward extending the capability of extant models and simulations, in-house and out-of-house, where appropriate.

- The MASTER structure would provide an adequate source of funding to extend the state-of-the-art in the M&S base, versus a situation where the PM allocates M&S funds at his or her discretion in an attempt to maximize short-term return.
- MASTER would focus national expertise in each model discipline to assure that needed model investments are not only funded, but also directed at extending the edges of the best models currently available.
- MASTER would free up some of the PM’s time and attention to other management responsibilities and let the Consortium provide the M&S support needed for their respective programs.
- MASTER would also help keep the government’s in-house laboratories responsive to real-time needs and allow the government to retain its smart-buyer capability, which it has been losing over the past decade.

Strength in Numbers

The MASTER concept also benefits from the fact that, with so many acquisition programs ongoing, a small percentage of each of these many programs ends up being a large source of M&S funds. These funds constitute an investment critical mass sufficient to serve the DoD much better than the many disjointed investments now ongoing in a host of individual programs.

Something to Think About, Something to Talk About

The thoughts I discuss in this article are presented to precipitate meaningful and open discussion. Clearly, they have some rough edges and need refining. For example, issues relating to the role of upgrades to private proprietary models, which are not owned or controlled by the DoD, need to eventually be addressed, but I don’t think this is an insurmountable issue. Hopefully, these ideas will serve as food for thought and eventually, once sufficiently refined, provide a catalyst for action.

Dr. Gansler was recently quoted as saying, “The biggest hurdle in achieving Simulation Based Acquisition is getting people to pay for the modeling and simulation. No one program wants to pay for something that benefits many.”⁶

The ideas set forth in this article might sound somewhat radical, but they do *incentivize* and *fund* the STEP and SBA concepts, which have become Pentagon policy in recent months and years.

We can’t afford to continue to talk in hopes that new money appears or that the PM will do something significant in M&S. There must be an incentive and a plan. After all, *aim at nothing, and we’re sure to hit it*.

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